

## SUBSPECIALTY PROCEDURES

# PATELLOFEMORAL ARTHROPLASTY

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### Abstract

**Background:** The first report of patellofemoral arthroplasty (PFA) was published in 1979<sup>1</sup>. Reviews in 2005 and 2007<sup>2,3</sup> called for studies comparing PFA with total knee arthroplasty (TKA) for isolated patellofemoral osteoarthritis. A blinded randomized controlled trial (RCT) was initiated in 2007 for this purpose, and the first report with 2-year results was awarded the Mark Coventry Award of the Knee Society in 2017<sup>4</sup>. It was found that (1) patients recover more quickly from PFA than from TKA; (2) during the first 2 years after surgery, PFA-treated patients have better average knee function than TKA-treated patients; and (3) PFA-treated patients regain their preoperative range of movement within the first postoperative year whereas TKA-treated patients do not regain it within the first 2 years<sup>4</sup>.

**Description:** There are general principles that are common to all brands of PFA implants. These include (1) an indication based on bone-on-bone contact in the patellofemoral joint with a preserved tibiofemoral joint; (2) replacing all surfaces of the patellofemoral joint, with metal on the femoral side and polyethylene on the patellar side; (3) ensuring a smooth transition from normal articular cartilage to the trochlear component; and (4) creating normal patellofemoral tracking.

**Alternatives:** The primary treatment of any degenerative condition should be nonoperative, but when such measures are insufficient surgical treatment may be indicated. Many procedures have been suggested for relieving patellofemoral pain, but if there is bone-on-bone contact in the patellofemoral joint, the only current surgical option (except for experimental treatments) is joint replacement—i.e., either PFA or TKA.

**Rationale:** Our general principle for joint replacement of the knee is to replace only the affected compartment if unicompartmental changes are found. If  $\geq 2$  compartments are affected, we perform TKA. This principle is challenged both by proponents of performing TKA in all cases of knee osteoarthritis and by proponents of bicompartamental knee replacement for 2-compartment disease. The 2-year results of our blinded RCT comparing PFA and TKA<sup>4</sup> support our current practice of PFA. In our practice, we have found PFA to be a rewarding

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procedure when the correct indications are used. PFA is likely to remain a fairly rare procedure, but any knee arthroplasty center should be able to offer it.

## Introductory Statement

Patellofemoral arthroplasty (PFA) performed for isolated patellofemoral osteoarthritis with the technique described below will result in quicker recovery, better knee function, and a better range of motion when compared with the results of total knee arthroplasty (TKA).

## Indications & Contraindications

### Indications

- The main indication for PFA is isolated patellofemoral osteoarthritis. Some patients with this condition have had long-lasting knee problems secondary to dysplasia with anterior knee pain and a history of dislocation of the patellofemoral joint, other cases are posttraumatic, but the majority of cases are idiopathic. Pain is the main symptom and is provoked by any activity that strains the patellofemoral joint, including walking on stairs (more so descending than ascending) and walking on uneven terrain (ranging from walking on a beach to mountain hiking). The patient also typically has pain, discomfort, and difficulty when rising from a low seat and may have found that riding a bicycle has become increasingly troublesome. A tangential radiographic projection of the patellofemoral joint (made with the knee at approximately 20° of flexion) should show bone-on-bone contact, and no substantial tibiofemoral degeneration should be found on either posteroanterior or lateral radiographs (Figs. 1-A, 1-B, and 1-C). Minor tibiofemoral osteophytes (Kellgren-Lawrence type I or II<sup>5</sup>) are not considered a definitive sign of tibiofemoral osteoarthritis, and only narrowing of the tibiofemoral joint line (Ahlbäck grade of >I)<sup>6</sup> or signs of osteonecrosis or osteochondritis preclude the radiographic definition of isolated patellofemoral osteoarthritis. On physical examination, the examiner often demonstrates bone-on-bone contact in the patellofemoral joint either by tapping the patella (Video 1) or by demonstrating catching and crepitus by moving the patella mediolaterally in a patient in whom longitudinal wear grooves have formed (Fig. 2). Tibiofemoral malalignment may be a contraindication for PFA, but there is no agreement on the limits of acceptable alignment. In our randomized controlled trial (RCT), we excluded patients with a clinical malalignment of >5°. The intraoperative assessment is important and allows the



Fig. 1-A



Fig. 1-B



Fig. 1-C

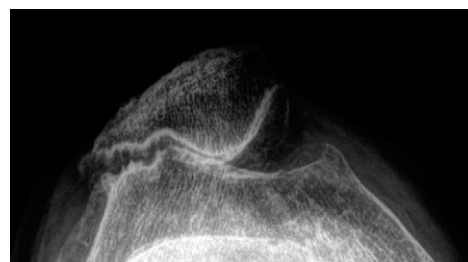


Fig. 2

**Figs. 1-A, 1-B, and 1-C** Radiographs of a knee with isolated patellofemoral osteoarthritis. **Fig. 1-A** Posteroanterior view. **Fig. 1-B** Lateral view. **Fig. 1-C** Tangential view.

**Fig. 2** Tangential radiograph showing severe patellofemoral osteoarthritis with longitudinal wear grooves.

**Video 1** Demonstration of bone-on-bone contact in the patellofemoral joint by tapping the patella.

definitive diagnosis of isolated patellofemoral osteoarthritis. We do not consider isolated chondral defects of the femoral condyles (with no corresponding lesion on the tibia) to be a contradiction for PFA, but only if their diameter is  $\leq 6$  mm (0.25 in) and they are surrounded by normal articular cartilage. If the intraoperative assessment shows substantial osteoarthritis in the tibiofemoral joint, TKA should be performed.

- Patellofemoral degeneration without bone-on-bone contact on a tangential radiograph is a debated indication for PFA. We rarely perform PFA in such cases. There may, however, be a place for the procedure when a magnetic resonance imaging (MRI) scan has shown severe articular cartilage degeneration with subchondral bruising on one or both sides of the patellofemoral joint. No such case was included in our RCT comparing PFA and TKA<sup>4</sup>.
- We have also occasionally performed the trochlear part of the procedure for a dislocating extensor mechanism after patellectomy in patients with severely dysplastic trochleae as described by Ackroyd et al.<sup>7</sup>.
- We do not consider chronic patellofemoral pain (e.g., chondromalacia, patellofemoral instability, or trochlear dysplasia) to be an indication for PFA in the absence of loss of articular cartilage from at least on one joint surface. In cases in which preoperative MRI was interpreted as showing severe degenerative changes or previous arthroscopy demonstrated exposed bone in the patellofemoral joint, but in which intact articular cartilage was found on arthrotomy, we have performed debridement and closed the joint without doing an arthroplasty.

### Contraindications

- Tibiofemoral instability is considered a contraindication. We would not perform a PFA in cases of clinically demonstrated sagittal or coronal instability than can reasonably be considered an explanation for at least some of the symptoms.
- Tibiofemoral malalignment with a varus or valgus deformity of  $>5^\circ$  from neutral is another contraindication. In cases of valgus deformity with isolated patellofemoral osteoarthritis, we have occasionally performed a valgus osteotomy before the PFA, but we consider this a specialist procedure.
- Tibiofemoral lesions of  $>6$  mm in diameter were considered a contraindication for PFA in the RCT<sup>4</sup>. It is unknown whether larger, isolated femoral lesions can be accepted for PFA when symptoms are mainly from the patellofemoral joint and when the lesions are treated with debridement, microfracturing<sup>8</sup>, or other cartilage surgery. We are hesitant to convert to a TKA if normal articular cartilage is found on the tibia, when the femoral lesions are truly local and surrounded by normal articular cartilage, and when the preoperative radiographs do not demonstrate joint space narrowing.
- Obviously, PFA is contraindicated if the patient does not consent to have the procedure, but we want to emphasize that the patient must also consent to having the fallback procedure if the intraoperative assessment shows that the knee is not suited for a PFA. In most cases, we ask for consent for a TKA with the patient accepting that the surgeon will make the final judgment of the appropriateness of a PFA intraoperatively. In our RCT comparing PFA with TKA<sup>4</sup>, about 25% of the patients were excluded intraoperatively because of tibiofemoral degenerative changes<sup>4</sup>. In rare borderline cases with no bone-on-bone contact on a tangential radiograph of the patellofemoral joint, we ask patients to consent to debridement as the fallback procedure if no or very mild degenerative changes are found intraoperatively.

## Step-by-Step Description of Procedure

### Step 1: Approach (Video 2)

*Position the patient, make the skin incision, and perform superficial and deep dissection.*

- Perform an examination of the range of motion and stability of the knee.
- Position the patient as for a TKA—i.e., supine with free movement at the hip. Use a foot support and a lateral plinth so that the extremity can rest with the knee bent at 90° to 110° (Fig. 3).
- Make a midline incision. It can be slightly shorter than the incision for a TKA with the medial parapatellar approach. Other approaches (e.g., subvastus or midvastus) may well be possible.
- Develop thick skin flaps and perform a medial parapatellar capsulotomy. This provides good access to the lateral gutter of the knee.
- Protect the medial meniscus and the articular cartilage on the medial femoral condyle during the capsulotomy.
- Expose as far distally as the intermeniscal ligament and proximally to expose the distal few centimeters of the anterior femoral cortex.
- The patella may be everted or just slid over the lateral femoral condyle for the remaining steps of the procedure, according to the preference of the surgeon.

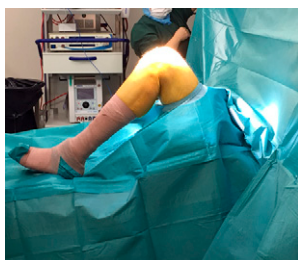


Fig. 3

**Fig. 3** Position of the extremity at the start of the procedure.

**Video 2** Approach for PFA.

## Step 2: Joint Assessment (Video 3)

*Determine if the knee is suited for PFA.*

- Perform a thorough assessment of the entire knee. Note the extent of degenerative changes in the patellofemoral joint. Inspect the medial and lateral compartments and note the state of the articular cartilage and the menisci, as one would do in an arthroscopy. Also assess the state of the cruciate ligaments.
- Exposed bone in the patellofemoral joint is usually on the lateral facet of the patella and superolaterally in the trochlea (Video 3). Rarely, bone is exposed medially in the patellofemoral joint (Fig. 4), which may be idiopathic or caused by iatrogenic overmedialization of the patella.



Fig. 4

**Fig. 4** View of a left knee from above (the surgeon's view). The trochlear wear is mainly in the medial part. Similarly, the patellar changes were also mainly medial. This wear pattern is unusual.

**Video 3** Inspection of the joint.

### Step 3: Preparation of Femur (Videos 4 through 9)

*Throughout this step, consider the 6 degrees of freedom that determine the position of the femoral component: 3 translations (transverse axis: mediolateral, anteroposterior axis: deep/proud, and longitudinal axis: proximal/distal) and 3 rotations (around the transverse axis: flexion/extension, around the anteroposterior axis: varus/valgus, and around the longitudinal axis: internal/external rotation).*

- Define the margins of the femoral notch and remove notch osteophytes if present.
- Remove large medial and lateral proximal femoral osteophytes.
- Preparation of the trochlea depends on the type of implant chosen, so the relevant technical manual must be consulted for details. Implants with a distal swallow-tail configuration allow the femoral component to be placed distally without interfering with the anterior cruciate ligament in knee extension while still retaining a broad surface for contact with the patellar component.
- Prepare the recess for the trochlear component and consider the 6 degrees of freedom. The following points are meant to be generic, but certain details are specific to the Avon implant (Stryker Orthopaedics).
  - Flexion/extension: Avoid placing the femoral component in extension; aim for a neutral or slightly flexed position. An extended position often results in proudness of the component distally. For the Avon implant, position the jig nose into the notch and the proximal outrigger flange flat onto the anterior femoral cortex (Video 4). Pass the femoral alignment rod through one of the holes in the up-post of the jig. The alignment rod should be parallel or slightly flexed relative to the anterior aspect of the femur, and the proximal part of the proximal outrigger should be parallel to the anterior femoral cortex (Video 4). Fix the jig with 1 central pin.
  - Internal/external rotation: Externally rotate the trochlear component by a few degrees, similarly to what is done in a TKA. Neutral or internal rotation may lead to anterior knee pain and maltracking (subluxation or even dislocation). The perpendicular to the anterior femoral cut should pass through the medial malleolus (Video 5). We have found that this ensures correct external rotation.
  - Attach and adjust the cutting block or jig. Both a stylus and an angel wing may be used (Video 5).
  - Medial/lateral position: Ensure that the distal part of the component is placed centrally over the top of the notch (Video 6).
  - Proximal/distal position: Place the trochlear component distally in the trochlea. Leave only 1 to 2 mm of native articular cartilage between the top of the intercondylar notch and the distal margin of the trochlear component (Video 6). If the distance from the component to the top of the notch is too large, the anterior cut of the femur may have to be adjusted to obtain the right position.
  - Anterior/posterior position: The transition from the native articular cartilage on the femoral condyles to the trochlear component should be perfectly smooth after insertion of the template (Video 7), trial component, and final component. If this is not the case, then place the component deep; avoid leaving it proud. A proud component will result in catching of the patella as the knee moves from flexion to extension, and the patient will feel clicking and discomfort during movement.

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**Video 4** Flexion/extension positioning of the femoral jig.

**Video 5** Setting the external rotation of the femoral cutting jig, attaching the saw guide, and performing the anterior cut.

**Video 6** Trochlear component sizing and position.

**Video 7** Outlining the contour of the trochlear component and preparing the bed for the inlay part of the femoral component.

**Video 8** Synovial fold and lateral peripatellar releases.

**Video 9** Preparing the patella.

- Varus/valgus position: This should be guided by the objective to obtain a smooth transition from the articular cartilage to the component surface both medially and laterally (Video 7). Adhere to this principle even if it means placing the component in slight valgus or varus. We have no exact limit on the deviation of the component axis from the quadriceps pull axis, but if the deviation is  $>15^\circ$  reassess the positioning and possibly accept placing the component slightly deep medially or laterally (never proud). In some cases, the surgeon finds severe wear of the proximal/anterior lateral femoral condyle secondary to lateral tracking of the patella. We have, in these cases, always been able to ensure a smooth implant-cartilage transition centrally and distally, but sometimes it is impossible to avoid having a step-off laterally because of osseous attrition. We accept this because the patella must track centrally at the end of the procedure and consequently will not be caught by the lateral step-off. You may smooth out the lateral step using bone cement during the cementation stage of the procedure. Specifically for the Avon implant, you may either use a freehand technique, outlining the contour of the implant with a knife or pen (Video 7), or use the punch available with the series-2 instruments. After outlining the contour, remove intact articular cartilage and subchondral bone with a combined use of osteotomes and curets. Other systems are available, including robotics. Remove enough bone to allow the trial component to sit flat against the anterior femoral cut and to be flush with or slightly recessed relative to the native articular surface distally. Once you are satisfied with the position, fix the template with 3 pins, drill lug holes, remove the template, and insert the trial component (Video 7).

#### Step 4: Preparation of Patella

*The patella must track centrally at the end of the procedure, and the main objectives of the patellar preparation are to ensure tracking and avoid overstuffing of the joint.*

- Perform the patella flip test by positioning the patella vertically in the fully extended knee. The patella will track as intended if it can be transposed to the midline of the trochlear component. If it cannot, perform releases. Three distinct patellar releases are routinely used in varying combinations: (1) lateral synovial fold release, (2) peripatellar release, and (3) midcapsular retinacular release. The default sequence should be in that order, and the flip test should be performed after each release.
  - Synovial fold release: Identify the lateral synovial fold by pulling the patella laterally using a retractor. The fold can be seen deep in the lateral gutter. Divide it sharply together with the thickened lateral patellotibial and patellofemoral bands. The intermediate lateral genicular artery is usually divided with the fold and should be electrocauterized (Video 8).
  - Peripatellar release: Pass a knife around the lateral edge of the patella at the insertion of the lateral retinaculum (Video 8).
  - Midcapsular release: This is a sharp release halfway between the 2 releases already done. We only perform this in more severe cases, in which it is sometimes necessary to extend the release distally into the fibers of the iliotibial tract.
  - We very rarely do an Elmslie-Trillat procedure (medialization of the tibial tuberosity) during the arthroplasty procedure. If this is found to be needed, use your preferred technique. We have had to do an Elmslie-Trillat procedure secondarily in a few cases because of persistent subluxation of the patella.
- After determining that the flip test can bring the patella to the midline, perform the patellar cut (Video 9). This is similar to resurfacing in TKA.
- Measure the patellar thickness (Video 9). We routinely use a jig to guide the cut, and we avoid doing the cut freehand. We aim for 11 to 14 mm of remaining patellar thickness, resulting in a composite thickness of 21 to 25 mm.

- In cases of severe attrition of the patella, we aim for a cut tangential to the more severely worn facet (Video 9). If  $<10$  mm is preserved, we keep the patellar cut superficial to this area and accept a thick cement layer. The cut should always be parallel to the anterior surface of the patella.
- If an asymmetrical patellar component is used, consult the manufacturer's recommendation for the correct rotation of the component. For the Avon implant, the long axis should, in the relocated position, be perpendicular to the movement trajectory of the patella. This is ensured by positioning the cutting jig perpendicular to the leg axis.
- Large lateral osteophytes should be resected. In the case of a very wide patella (e.g., after a fracture), you may consider performing a partial facetectomy to reduce the width to that of the patellar component.

### Step 5: Implant Insertion

*Insert the trial implants, test the knee, and insert the definitive implants.*

- After preparation of the femur and patella, insert trial components and assess the tracking. The patella must track centrally in the trochlea during the entire range of motion. If the patella does not track centrally, there may be an issue with the trochlear position; the most common mistake is insufficient external rotation. The 2 implants should be in contact in flexion up to at least  $90^\circ$ , and normally approximately  $100^\circ$ , after which the patella passes over the native articular cartilage of the femoral condyles. When extending the knee, carefully determine if proudness of the trochlea results in catching of the patella, which may be demonstrated by a click or by the patella being pushed laterally. You may provisionally close the capsule proximomedially to the patella, but we caution against accepting the patellar tracking if it depends solely on the capsulorrhaphy.
- Prepare the osseous surfaces for the implant. When using cement, consider drilling holes in eburnated areas to improve cement penetration. Bone surfaces should be pulse-lavaged and dried before cementation (Video 10).
- Using a pressurized cementation technique, insert the component and maintain compression until the cement has polymerized (Video 10).
- Test the range of motion, patellar tracking, and contact between the patellar and femoral components (Videos 11 and 12).

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**Video 10** Cementation of implants.

**Video 11** Removal of excess cement and patellar tracking.

**Video 12** Demonstration of patellofemoral tracking.

## Step 6: Closure

*Perform routine closure.*

- We use local infiltration analgesia<sup>9</sup> (Video 13) and tranexamic acid, and we do not use drains.
- We use continuous sutures for closure (Video 14), as we believe that this distributes forces evenly in the capsule. The capsulorrhaphy should not be needed for normal patellar tracking; it is merely for closure of the capsule.
- After closing the capsule, observe the spontaneous flexion of the knee by flexing the hip to 90° (Video 15).
- We also use continuous sutures for the superficial fascia and staples for the skin.

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**Video 13** Local infiltration of analgesics.

**Video 14** Closure.

**Video 15** Checking the range of motion.

## Step 7: Postoperative Care

*PFA is well-suited for early mobilization and enhanced recovery.*

- We routinely perform these operations as day surgery using the principles of rapid recovery. This depends on good surgical technique, bleeding control by tranexamic acid, adequate pain control using local infiltration analgesics, and a well-informed patient.
- The patient is allowed full weight-bearing and a full range of motion as soon as they start mobilizing, only hours after the surgery. Crutches are used as needed (Video 16).

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**Video 16** Patient walking only hours after surgery.

## Results

The 2-year results of our blinded randomized study comparing PFA and TKA have been published previously<sup>4</sup>. In our practice, we have found PFA to be a very rewarding procedure when it was performed for the correct indications. Although the procedure is likely to remain relatively rare, any knee arthroplasty center should be able to offer it.

## Pitfalls & Challenges

- The main pitfall is performing the procedure for the wrong indication. In the learning phase, operate only on patients with clear bone-on-bone contact in the patellofemoral joint. If, after opening the tibiofemoral joint, you find substantial degenerative changes, then change the procedure to a TKA. For this reason, always reserve TKA instruments and implants for these cases. Also, always obtain the patient's consent for a fallback procedure to avoid the risk of not doing the right operation.
- Avoid positioning the trochlear component in extension, as this could cause catching of the patella as the knee moves from flexion to extension. The postoperative radiograph should show that the distal part of the trochlear component extends to or slightly beyond the Blumensaat line (Fig. 5).
- Avoid leaving the trochlear component proud, as this also leads to catching and a “hop” of the patella as the knee moves from flexion to extension.
- Avoid any temptation to rotate the trochlear component into valgus or varus with the consequence of leaving it proud. The main objective of varus/valgus rotation is to ensure the smooth transition from native articular cartilage to the component.
- Make sure that the patella tracks normally over the femur before closing the capsule.
- All modern trochlear components are of an inlay type at the junction between the native articular cartilage and the component surface. Many are of an onlay type in their proximal part. There is an additional class of truly inlay components that are meant to replace the damaged articular cartilage only, resulting in a component surrounded by normal articular cartilage. The goal for all of the implant types is a smooth transition from the articular cartilage to the implant for the patella to move over.



Fig. 5

**Fig. 5** Postoperative lateral radiograph of the patient shown in Figures 1-A, 1-B, and 1-C. Note that the distal part of the trochlear component extends slightly beyond the Blumensaat line.

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